PATENT
Attorney Docket No. 211467-00211 (12-1100)

IN THE U.S. PATENT AND TRADEMARK OFFICE

Application No.:	09/833,372
Filing Date:	April 12, 2001
Inventor(s):	Wojtowicz
Group Art Unit:	2815
Examiner Name:	Baumeister, Bradley W.
Customer No.:	27160

Title: GaN HBT Superlattice Structure

Confirmation No.: 3137

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO NOTIFICATION OF NON-COMPLIANT APPEAL BRIEF

Sir:

In response to the Notification of Non-Compliant Appeal Brief mailed on December 27, 2005, please find a revised copy of the Appeal Brief, that has been revised to overcome the objection in the aforementioned Notification.

Because the fee for filing the Appeal Brief was deducted from Deposit Account No. 50-1214 on July 13, 2005, it is believed no further fees are required; however, the Commissioner is authorized to charge any additional required fees (or credit overpayments) to Deposit Account No. 1214.

Respectfully submitted,

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By: 

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

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Real Party In Interest

The real party in interest is Northrop Grumman Corporation, by virtue of an Assignment from the inventor Michael Wojtowicz to TRW Inc., recorded on Reel/Frame 11702/297 and from TRW, Inc., to Northrop Grumman Corporation recorded on Reel/Frame 013751/0849.

Related Appeals and Interferences

There are no other appeals or interferences known to the Appellant or the Appellant's representative, which are believed to directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

Status Of Claims

Claims 1-5 and 8-11 are pending. The final rejection of these claims forms the basis for this appeal. In particular, claims 1, 8 and 9 stand rejected under 35 U.S.C. §103 as being unpatentable over Song U.S. Patent No. 6,410,944 ("Song") in view of either Japanese Patent

Publications JP 4-251934 ("JP '934") or JP 63-248164 ("JP '164"). Claims 1, 5, 8 and 9 stand rejected under 35 U.S.C. 103(a) as being unpatentable over the Song and either JP '164 or JP '934 and further in view of Razeghi U.S. Patent No. 5,831,277 ("Razeghi"). Claims 2-4, 10 and 11 stand rejected under 35 U.S.C. 103(a) over the Song and Razeghi patents and either JP '164 or JP '934 and further in view of Ohta U.S. Patent No. 4,620,206 ("Ohta").

Status Of Amendments

All amendments have been entered. The claims as currently amended are attached as an Appendix.

Summary Of Claimed Subject Matter

The present invention relates to a heterojunction bipolar transistor (HBT) 20 as illustrated in Fig. 1 and described in paragraphs [0013]-[0016] on pages 3 and 4 of the specification, having a relatively higher efficiency and higher frequency operation without the fabrication complexities of known HBTs. The subject matter of all of the claims on appeal is illustrated in Fig.1 and described in paragraphs [0013]-[0016] on pages 3 and 4 of the specification. None of the claims on appeal are in means plus function format. With reference to Fig. 1, the HBT 20 includes a substrate 22, a n^+ gallium nitride (GaN) subcollector 24 formed on top of the substrate 22. An n-GaN collector layer 26 is formed on top of the subcollector layer 24. In accordance with an important aspect of the invention, a base layer 28 is formed with non-constant band gap energy with a relatively low value at the collector base interface 30 and a higher value at the emitter base interface 32 in order to create an electrostatic field in the base to increase the carrier velocity and decrease the transit time of the device. The base layer 28 is formed from a superlattice consisting of alternating layers of AlGaN/GaN. An emitter layer 34 is formed on top of the base layer 28. The emitter layer 34 is formed from AlGaN. A collector contact 36 is formed on top of the subcollector layer 34 while a base contact 38 is formed on top of the base layer 28. An emitter contact 40 is formed on top of the emitter layer 34. The configuration of the device increases the injected electron transit time and at the same time increases the p-type carrier concentration to improve the operation efficiency of the device.

Grounds of Rejection to be Reviewed on Appeal

I. Whether the Board should reverse the rejection of claims 1, 8 and 9 under 35 U.S.C. 103(a) as being unpatentable over the Song patent and either JP '164 or JP '934.

II. Whether the Board should reverse the rejection of claims 5 (and claims 1, 8 and 9 alternatively) under 35 U.S.C. 103(a) as being unpatentable over the Song patent and either JP '164 or JP '934 and further in view of the Razeghi patent.

III. Whether the Board should reverse the rejection of claims 2-4, 10 and 11 under 35 U.S.C. 103(a) as being unpatentable over the Song and Razeghi patents and either JP '164 or JP '934 and further in view of the Ohta patent.

It is respectfully submitted that the claims are grouped according to the rejections and that all of the claims in each of the groups stand or fall together.

Argument

I. Rejection of Claims 1, 8 and 9 under 35 U.S.C. §103(a) as being unpatentable over the Song Patent in view of either Japanese Publication JP' 164 or JP '934.

It is respectfully submitted that the claims are grouped according to the rejections and that all of the claims in each of the groups stand or fall together.

Claims 1, 8 and 9 have been rejected under 35 U.S.C. §103(a) as being unpatentable over the Song patent in view of either JP '934 or JP '164.It is respectfully submitted that none of the references either singly or in combination disclose or suggest all of the limitations recited in the claims at issue, in contravention of MPEP § 2143. In addition , it is also respectfully submitted that the Examiner is impermissibly combining teachings of references that disclose semiconductors formed from material systems different from the material system claimed using the claims as a blueprint. Accordingly, the Board is respectfully requested to reverse the Examiner's rejection of claims 1, 8 and 9.

The claims at issue all relate to a heterojunction bipolar transistor (HBT) based on a GaN/AlGaN material system. For the convenience of the Board, Fig. 1 of the instant application is repeated below.

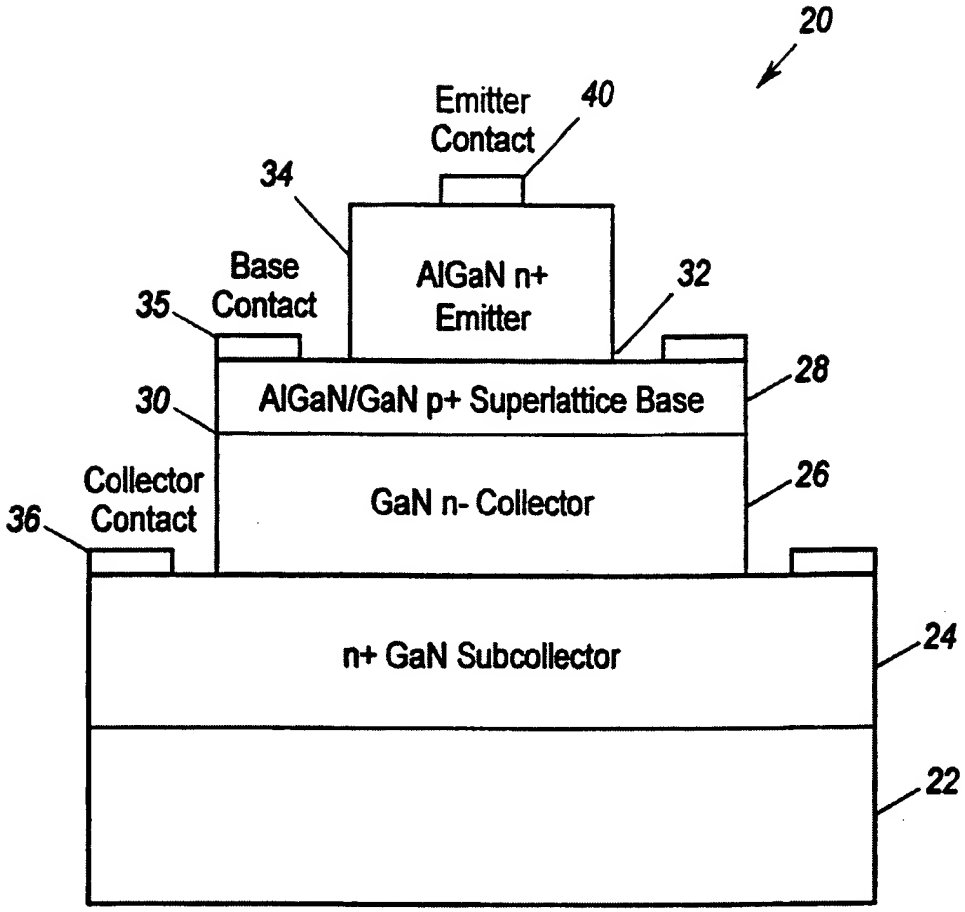


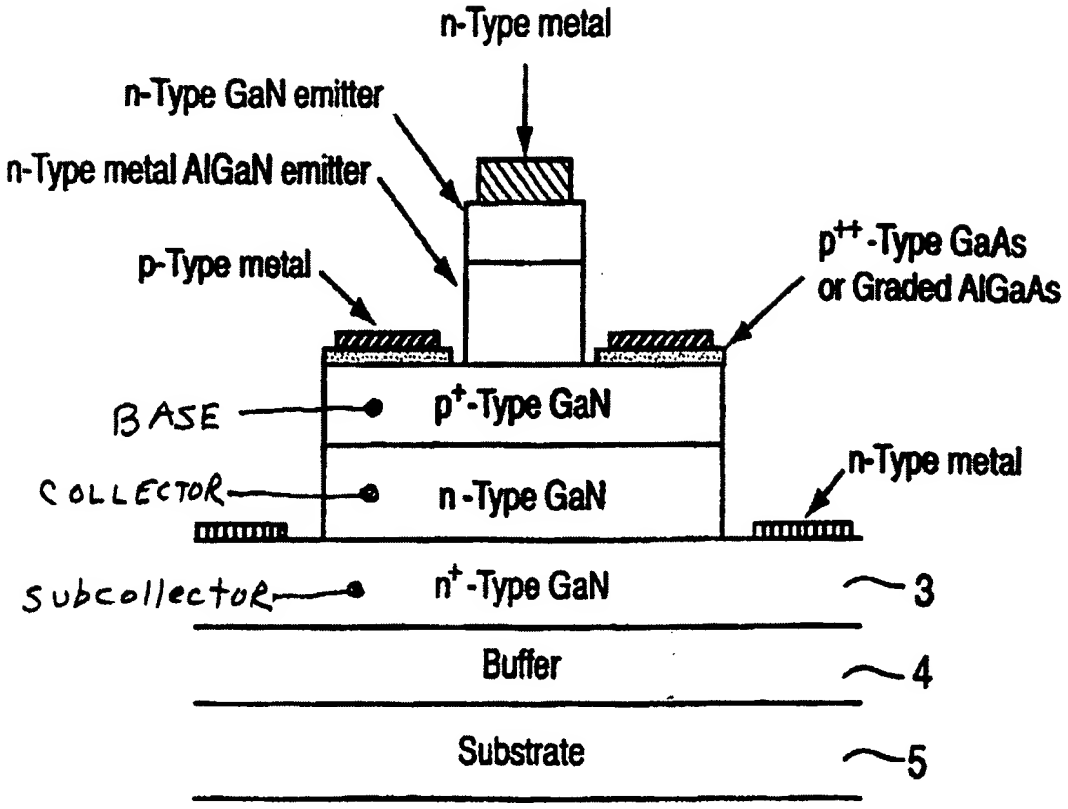
FIG. 1

The structure recited in the claims at issue exclusively relates to a AlGaN/GaN material system. An important aspect of the claimed invention relates to the limitation that the base layer 28 is formed from a supperlattice of alternating layers of AlGaN/GaN.

The primary reference cited by the Examiner is the Song patent. In the final Office Action, mailed on November 9, 2004, the Examiner relies on FIG. 3 of the Song patent in support of the rejection. For the convenience of the Board, FIG. 3 of the Song patent is illustrated below.[1/]

[1/] The Applicant has identified the base, collector and subcollector layers of FIG. 3 of the Song patent in the same manner as identified in paragraph 3(a) of the Detailed Action.

FIG. 3



As the Board will kindly note, the Song patent discloses a GaN base layer, unlike the structure recited in the claims at issue, which recite that the base layer is formed from a superlattice. In fact, paragraph 2a of the Detailed Action acknowledges that the Song patent does not disclose AlGaN/GaN superlattice base layer.

There are also other differences between the structure disclosed in the Song patent and the invention. For example, the Song patent discloses a two layer emitter with one layer formed from AlGaN and a second layer formed from GaN. The invention, on the other hand, discloses a homogeneous emitter layer formed from AlGaN.

In support of the obviousness rejection, the Examiner cites JP '934 and JP '164, **neither of which discloses a AlGaN/GaN superlattice base layer.** These references were cited for disclosing superlattice structures. The superlattice structures are formed from different materials, InP/InGaAs and AlGaAs/GaAs, the same materials used for the emitter and collector.

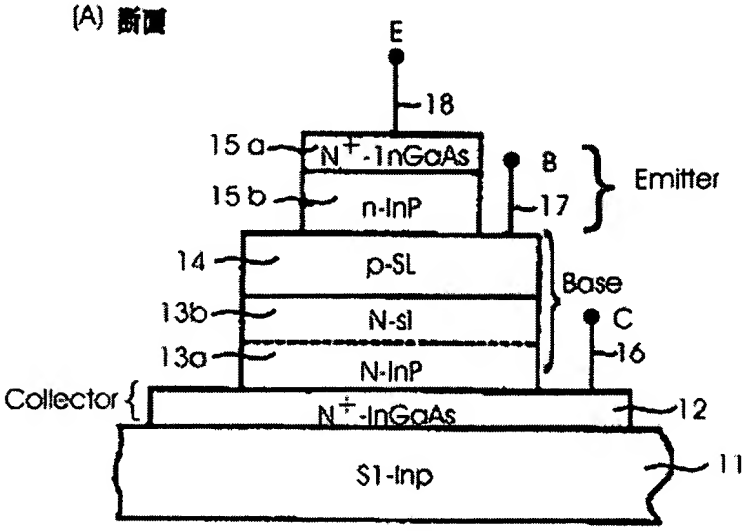
Each of these references is discussed and illustrated below. Fig. 2 of the JP '934 publication is provided below for the convenience of the Board.

特開平4－251934

[図2]

実施例

(A) 断面



The Japanese patent publication JP '934 discloses a **InP/InGaAs** material system, which is totally different than the **AlGaN/GaN** material system recited in the claims at issue. Moreover, the structure of the other layers of the device disclosed in the JP '934 reference are different than the claims at issue. With reference to the Fig. 2 above and the English abstract provided by the Examiner, it appears that that the emitter is formed in two layers, identified with the reference numerals 15a and 15b. The layer 15a is formed from InP, while the layer 15b is formed from

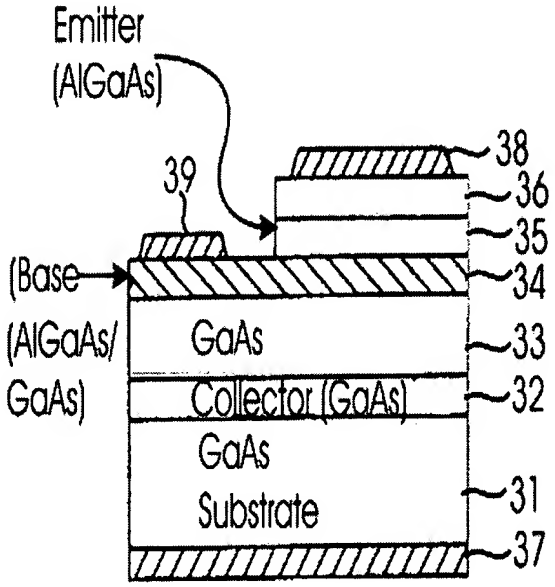
InGaAs. The collector layer, identified with the reference numeral 12, is also formed from InGaAs. As shown in Fig. 2 above, the base layer appears is actually formed from three layers 13a, 13b and 14. The layer 13a is formed from InP. The layers 13b and 14 are identified as "SL", presumably superlattice. The English abstract indicates that the superlattice is formed from InGaAs/InP. The English abstract further indicates that the base layer also includes a "local band structure of a uniform composition"; presumably the InP layer 13a.

Not only does the JP '934 reference not disclose AlGaN/GaN superlattice base layer, as recited in the claims at issue, it is respectfully submitted that the Examiner is picking and choosing among the teachings in this reference and reading more into the reference than it actually teaches. In particular, the Examiner relies on the JP '934 patent for teaching a base layer formed as a superlattice formed from the same materials as the emitter and collector layers. In essence, the Examiner's logic is that since the JP '934 reference teaches a base layer formed as a superlattice formed from the same materials as the collector and the emitter, the present invention is obvious because the base superlattice is formed from the same materials as its collector and emitter layers, even though those materials are not disclosed in the reference. It is respectfully submitted that there are several flaws in this logic. First, this logic omits the fact that the base layer disclosed in the JP '934 reference also includes the layer 13a, an InP layer. The Examiner has not shown where the reference teaches the use of the superlattice without the InP layer. Second, the Examiner simply assumes that the teachings of patents relating to semiconductor devices made with different material systems are interchangeable. In particular, the Japanese patent publication JP '934 relates to InP/GaAs/InGaAs material system, while the invention recited in the claims at issue relate to a GaN/AlGaN material system. There is absolutely no disclosure or suggestion in either the Song patent or the JP '934 reference or any of the other references of record that the teachings in the references are readily combinable with each other despite the fact that the teachings relate to different material systems. In fact, it is well-known in the semiconductor art that the properties of one material system are not transferable to other material systems in semiconductor fabrication.

The other Japanese publication JP 63-248164 is illustrated and discussed below.

特開昭 63-248164 (6)

第 3 図



The Japanese patent publication JP '164 also discloses a material system that is different from the material recited in the claims at issue. In particular, the Japanese patent publication JP '164 discloses a **AlGaAs/GaAs** material system where the claims at issue recite a **GaN/AlGaN** material system.

Moreover, none of the references disclose the interfaces as recited in the claims at issue. In particular, the specific base collector and base emitter interfaces as recited in the claims at issue.

Also, it is respectfully submitted that the Examiner has failed to establish a *prima facie* case of obviousness as set forth in MPEP § 2142 and § 2143. In order to establish a *prima facie* case of obviousness, three criteria must be met as set forth in MPEP § 2143.

> "First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.
>
> The teaching or suggestion to make the claimed combination reasonable expectation of success must both be found in the prior art, not in the Applicant's disclosure."

It is respectfully submitted that the examiner is combining two and three references in support of the rejections without a showing that the motivation for the combination was suggested by the reference itself. Moreover, none of the references, either singly or in combination, teach all of the elements of the claims. For example, all of the claims recite a **AlGaN/GaN** superlattice base layer with a GaN collector layer and a AlGaN emitter layer defining base collector and base emitter interfaces. None of the references cited disclose the **AlGaN/GaN** superlattice base and the cited interfaces. Moreover, it is respectfully submitted that the Examiner has failed to provide a reference that shows that the teachings of one material system are applicable to a different material system. Indeed, as is extremely well known in the art, different materials have different properties, which is why the teaching of one patent with a material system are not transferrable to other material systems as suggested by the Examiner. For all of the above reasons, the Board is respectfully requested to reverse the Examiner's rejection of claims 1, 8, and 9.

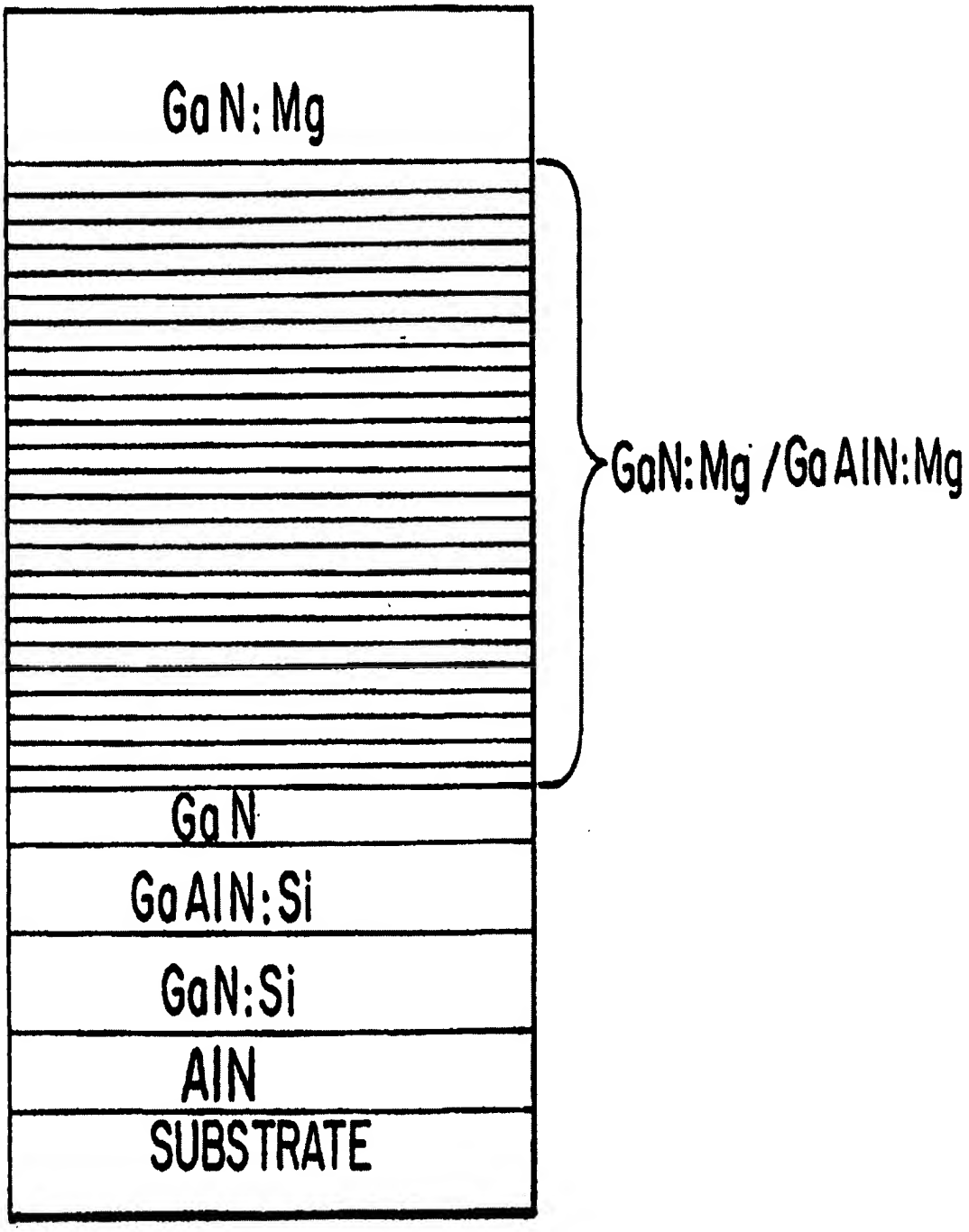
II. Rejection of Claim 5 (and alternatively Claims 1, 8 and 9) under 35 U.S.C. § 103(a) as being Unpatentable over Song and Either JP '164 or JP '934 and Further in View of Razeghi.

Claim 5 (and claims 1, 8 and 9 alternatively) have been rejected under 35 U.S.C. § 103(a) as being unpatentable over the Song patent in view of either JP '164 or JP '934 and further in view of the Razeghi patent.

Claim 5 is similar to claim 1, and additionally recites that the substrate is formed from materials selected from the group consisting of sapphire and silicon carbide. In particular, claim 5 recites a base layer formed from a AlGaN/GaN superlattice and defines base collector and emitter base interfaces where in the collector layer is formed from GaN and the emitter layer is formed from AlGaN.

Claim 5 has been rejected under the Song reference as well as the Japanese patent publication '934 or, alternatively, the Japanese patent publication, JP '164 further in view of Razeghi patent. It is respectfully submitted that for the same reasons set forth above, claim 5 defines patentable subject matter over the Song reference as well as the Japanese patent publications, either individually or collectively. The Razeghi patent was apparently cited by the Examiner as disclosing a superlattice formed from AaGaN/GaN. However, as clearly shown in the figures of the Razeghi patent, in which the superlattice is doped with Mg. Moreover, the Razeghi patent does not disclose the structure recited in the claims at issue. For example, the Razeghi patent does not disclose a AlGaN emitter layer or a GaN collector layer. In fact, the Razeghi patent does not refer to an HBT at all, but rather simply a high-nitride superlattice structure. For these reasons and the above reasons, the examiner is respectfully requested to reconsider and withdraw the rejection of claim 5.

The sole figure of the Razeghi layer is repeated below for the convenience of the Board.



Again, it is respectfully submitted that none of the references including the Razeghi reference disclose or suggest the specific superlattice layer of AlGaN/GaN recited in the claims at issue. For these reasons and the above reasons, the Board is respectfully requested to reverse the Examiner's rejection of claim 5.

III. Rejection of Claims 2-4, 10 and 11 under 35 U.S.C. § 103(a) as being unpatentable over Song and either JP '934 or JP '164 and further in view of the Ohta patent.

Claims 2-4, 10 and 11 have also been rejected over the Song patent and further in view of the Japanese patent publications JP '934 and JP '164 in further in view of Ohta, et al., U.S. Patent No. 4,620,206. The Ohta patent was cited for teaching "that either barrier-thickness-grading or barrier-composition-grading can be employed in superlattices to produce effective ban gap changes in superlattice structures." Again, it is respectfully submitted that the Examiner is attempting to apply broad teachings irrespective of the material system to which the teachings apply without providing any reference whatsoever that these teachings are applicable to other material systems. The Ohta patent, for example, is specific to a particular material system. For example, at Column 1, Lines 24-26, it states: "in this device, the Gunn is determined solely by the energy band structure of the material, ..." In fact, all of the references cited by the Examiner do not mention that their teachings are applicable to other material systems. Furthermore, the claims of all of the cited patents are limited to specific material systems which further demonstrates the Applicant's position.

Conclusion

The Board is respectfully requested to reverse the rejections of all claims by the Examiner.

Respectfully Submitted,

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Date: March 1, 2006

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Appendix A
Claims On Appeal

1. A heterojunction bipolar transistor (HBT) comprising:

a substrate;

an n+ doped GaN subcollector layer;

an n- doped GaN collector layer;

a p+ doped base layer formed on top of said collector layer defining a base collector interface formed from alternating layers of A1GaN/GaN forming a superlattice;

an n+ doped A1GaN emitter layer formed on top of said base layer defining an emitter base interface;

a base contact formed on said base layer;

a collector contact formed on said subcollector; and

an emitter contact formed on said emitter.

2. The HBT as recited in claim 1, wherein the Al concentration in said AlGaN layers is irregular.

3. A heterojunction bipolar transistor (HBT) comprising:

a substrate;

an n+ doped GaN subcollector layer;

an n- doped GaN collector layer;

a p+ doped base layer formed on top of said collector layer defining a base collector interface formed from alternating layers of A1GaN/GaN forming a superlattice;

an n+ doped A1GaN emitter layer formed on top of said base layer defining an emitter base interface, the A1 concentration at said emitter base interface being greater at said emitter base interface than said base collector interface;

a base contact formed on said base layer;

a collector contact formed on said subcollector; and

an emitter contact formed on said emitter.

4. The HBT as recited in claim 1, wherein said alternating AlGaN layers are formed such that the A1 concentration is graded.

5. A heterojunction bipolar transistor (HBT) comprising:

a substrate formed from a material selected from the group consisting of sapphire and silicon carbide;

an n+ doped GaN subcollector layer;

an n- doped GaN collector layer;

a p+ doped base layer formed on top of said collector layer defining a base collector interface formed from alternating layers of A1GaN/GaN forming a superlattice;

an n+ doped A1GaN emitter layer formed on top of said base layer defining an emitter base interface;

a base contact formed on said base layer;

a collector contact formed on said subcollector; and

an emitter contact formed on said emitter.

8. A method for fabricating a heterojunction bipolar transistor comprising the steps:

(a) forming a subcollector layer on a substrate;

(b) forming a collector layer on said collector layer;

(c) forming a base layer as a superlattice of alternating layers of A1GaN/GaN on said collector defining a base collector interface; said base layer formed with an irregular band gap energy;

(d) forming an emitter layer on said base layer defining a base collector interface; and

(e) forming contacts on said base, subcollector said emitter layers.

9. A method for fabricating a heterojunction bipolar transistor comprising the steps:

(a) forming a subcollector layer on said substrate;

(b) forming a collector layer on said subcollector layer;

(c) forming a base layer comprising a superlattice of alternating layers of A1GaN/GaN having a non-constant concentration of A1 in said alternating layers of A1GaN/GaN on said collector defining a base collector interface; said base layer formed with an irregular band gap energy;

(d) forming an emitter layer on said base layer defining a base collector interface; and

(e) forming contacts on said base, subcollector said emitter layers.

10. The process as recited in claim 9, wherein step (c) comprises forming said base layer with an A1 concentration at said base collector interface being less than the A1 concentration at said base emitter interface.

11. A method for fabricating a heterojunction bipolar transistor comprising the steps:

(a) forming a subcollector layer on a stubstrate;

(b) forming a collector layer on said subcollector layer;

(c) forming a base layer comprising a superlattice of alternating layers of AlGaN/GaN having a non-constant concentration on Al in said alternating layers of AlGaN/GaN on said collector defining a base collector interface such that the Al concentration is graded between said base collector interface and said emitter base interface said base layer formed with an irregular band gap energy;

(d) forming an emitter layer on said base layer defining a base emitter interface; and

(e) forming contacts on said base, subcollector and emitter layers.

Appendix B
Evidence Appendix

None

APPENDIX C
RELATED PROCEEDINGS APPENDIX

None